



TRANSFORMATIONAL SYSTEM CONCEPTS AND TECHNOLOGIES FOR FUTURE SPACE APPLICATIONS

Presented by:
Joe Howell

Authors:

John C. Mankins ⁽¹⁾

Joe T. Howell ⁽²⁾

⁽¹⁾ NASA Headquarters, Exploration Systems Mission Directorate

⁽²⁾ NASA Marshall Space Flight Center, Future Concepts Office

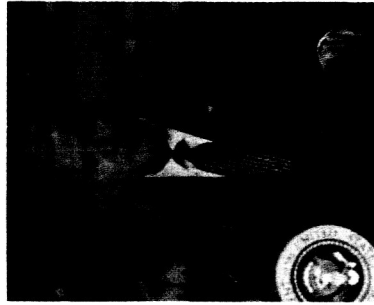
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Vision for Space Exploration

Excerpts from The President's Vision for U.S. Space Exploration

- Implement a sustained and affordable human and robotic program
- Develop supporting innovative technologies, knowledge, and infrastructures
- Develop and demonstrate power generation, propulsion, life support, and other key capabilities for long duration, more distant human and robotic missions



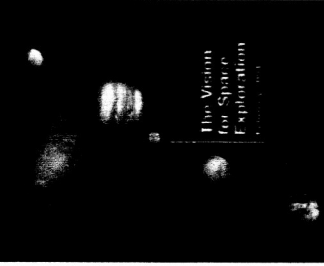
Excerpts from "Vision for Space Exploration" – Sean O'Keefe

Policy Objective (Technology)

"Develop the innovative technologies, knowledge, and infrastructures both to explore and to support decisions about the destinations for human exploration..."

National Benefits (Technology)

"The space missions in this plan require advanced systems and capabilities that will accelerate the development of many critical technologies, including power, computing, nanotechnology, biotechnology, communications, networking, robotics, and materials."



Exploration Building Blocks

"To support these missions, a number of key building blocks are necessary. These include new capabilities in propulsion, power, ..."

Excerpt from Packard Commission

Findings

- Apply technology to lower the cost of the system, not just to increase its performance
- Mature technology prior to entering engineering and systems development

Establishing Human and Robotic Space Exploration



TRANSFORMATIONAL SYSTEM CONCEPTS AND TECHNOLOGIES

Need for Transformational Systems

- **Goal**

To meet the challenges of the Vision for Space Exploration

- **Objective**

Rapid development and delivery of robust, adaptable, cost-effective spacecraft and flight hardware suitable for a broad variety of missions

- **Critical Bridge**

Technology Maturation Program is the critical bridge between development of technology and its infusion into the systems that will make the Vision for Space Exploration a reality



TRANSFORMATIONAL SYSTEM CONCEPTS AND TECHNOLOGIES APPROACH

- A promising approach to transforming space systems is the planning and evolution into a meaningful stepping stone design, development, and implementation process.
- New systems concepts and technologies are needed to achieve NASA's Vision and Mission.
- Several workshops have pursued transformational technologies and opportunities to change paradigms.
 - To focus on identifying new concepts and technologies and 'vetting' the basic concept that a transformation in how the US approaches space exploration, research and discovery is possible.
 - To focus on identifying and assessing candidate technology options and opportunities for the future.
 - To focus on how best to frame "mission case studies" that apply technologies (new or existing) in novel ways within 'transformational systems concepts' or existing systems concepts.



TRANSFORMATIONAL SYSTEM CONCEPTS AND TECHNOLOGIES

Examples

- **Modular Systems**
- **Propellant Depots**
- **Surface Systems**
- **Infrastructure**



TRANSFORMATIONAL SYSTEM CONCEPTS AND TECHNOLOGIES

Modular Systems

- Modular systems are a key to success of transformational paradigms
- Reconfigurable modular hardware, coupled with reprogrammable, modular software based on wireless communications locally and networking (local and remote)
- Seamless human-machine interfaces (ubiquitous)
- Long-life, high-reliability and robust humans-in-space systems
- Advanced information technologies, including
 - _ Archiving of 'fleet' operational data concerning performance and problems
 - _ Readily accessible database(s)
 - On operational details, or On system design, performance, failure information
 - _ "Inter-fleet element" autonomous information exchange capabilities



Space Solar Power Modular Systems





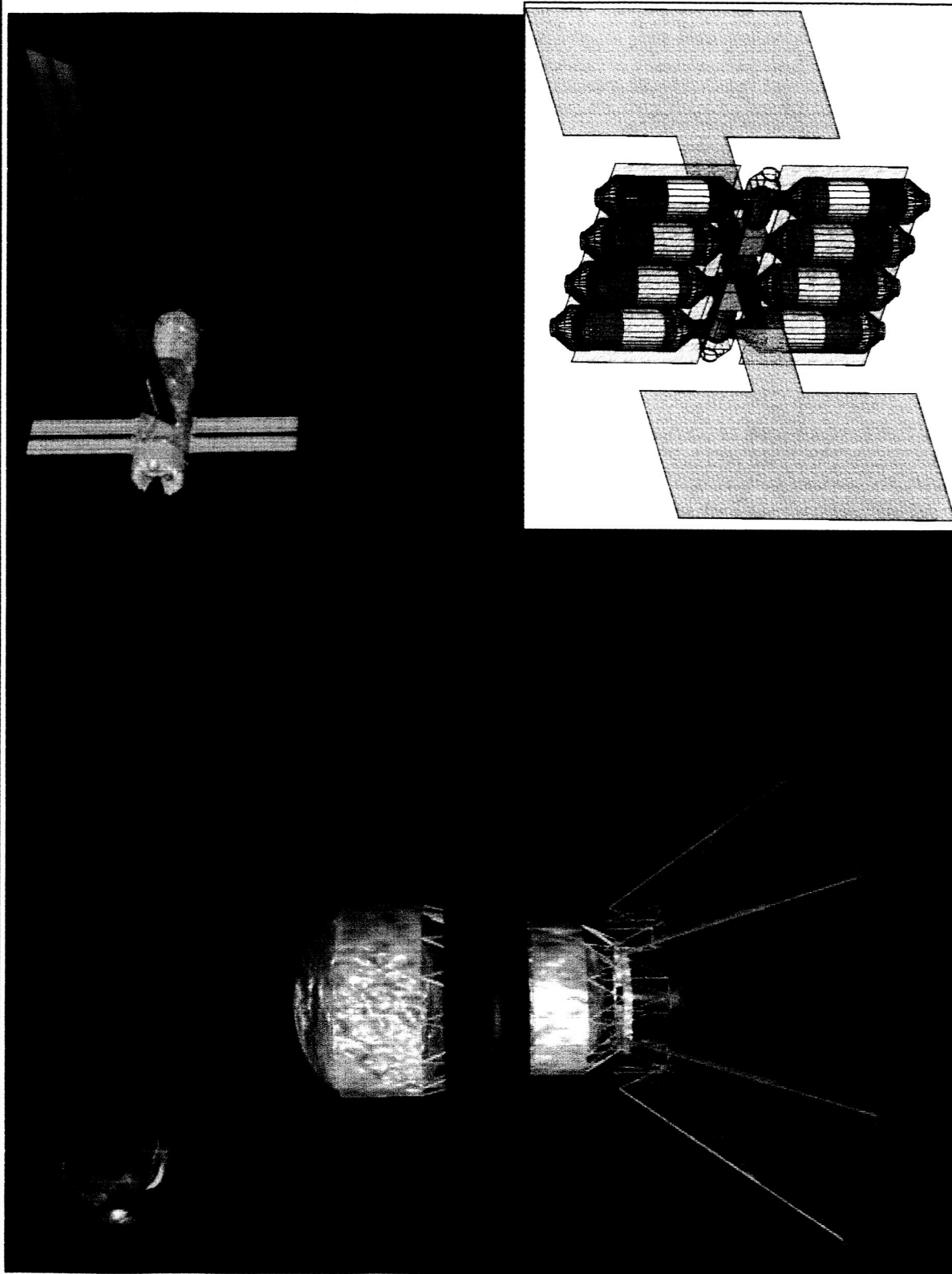
TRANSFORMATIONAL SYSTEM CONCEPTS AND TECHNOLOGIES

In-Space Cryogenic Depot

- Will enable more ambitious and affordable human and robotic exploration of the Moon and beyond
 - Critical to this endeavor is the ability to produce, store, and preposition propellants in space
- Will provide the capability to produce, store and preposition, and utilize propellants, and other consumables-food or equipment-for Earth –Neighborhood campaigns and beyond
 - Low-gravity cryogenic fluid management (CFM) technologies is a fundamental requirement for establishing a robust in-space cryogenic depot space exploration infrastructure
- The scope of the activity will lay the framework for a flight demonstration of CFM technologies



Cryogenic Propellant Depots





TRANSFORMATIONAL SYSTEM CONCEPTS AND TECHNOLOGIES

Surface Systems

- Surface systems provide the capability to conduct long term exploration missions
- Example surface systems include: Power stations, habitats, green houses, and in-situ resource utilization (ISRU) systems
- A "spiral development" approach will deploy surface systems that lead from short stays and meeting basic necessities to long term commercialization and colonization
- Initial systems will be framed in the context of a broad vision of future missions and systems



Laser Power Beaming for Lunar Rover Applications





Lunar Depot Applications





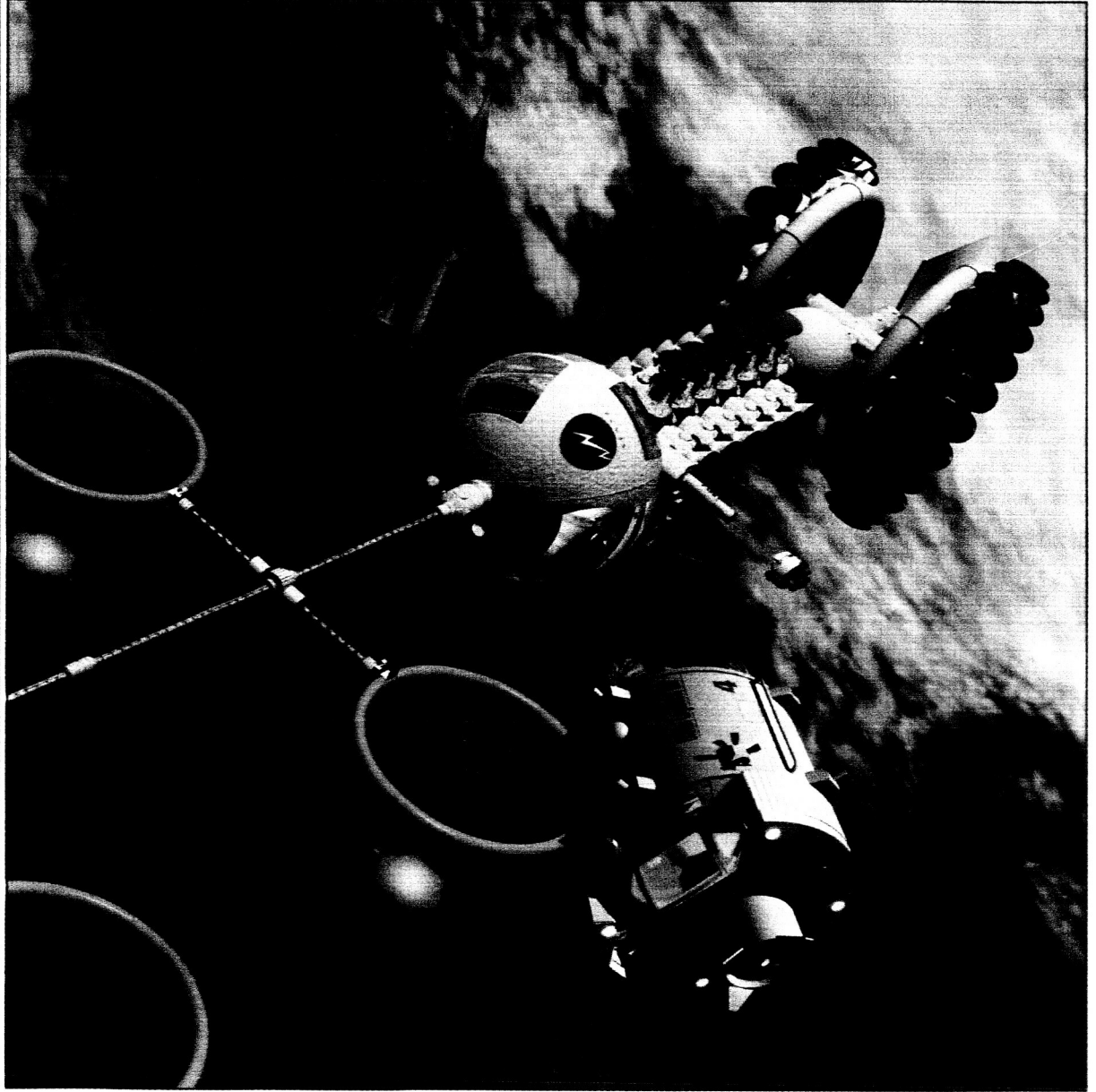
TRANSFORMATIONAL SYSTEM CONCEPTS AND TECHNOLOGIES

Infrastructure

- Infrastructures provide services to a broad range of customers. Example services include: Power, communications, transportation, and information
- Will be developed over many years and by diverse organizations
- Will represent critical "building block capabilities" for future human and robotic space exploration
- Will be developed using a "spiral development" approach adapted from a process of strategic systems management first applied within the U.S. Department of Defense (DOD)
- Initial systems within a space infrastructure will be framed in the context of a broad vision of future missions and systems



Space Exploration & Commercial Development





Summary

- Throughout history, dramatic and steady infrastructure transformations have been accomplished, i.e., power, transportation, communication, etc., without which the world would be a drastically poorer and harsher home for humanity
- The President's Vision for Space Exploration offers opportunities to seek new paradigms and develop transformational space infrastructures
- First steps are being taken to develop transformational system concepts such as modular reconfigurable systems, cryogenic propellant depots to preposition propellants, etc., and to develop other critical technologies